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EVALUATING 1 AND 2D DIMENSIONAL MODELS FOR FLOODPLAIN INUNDATION MAPPING

by

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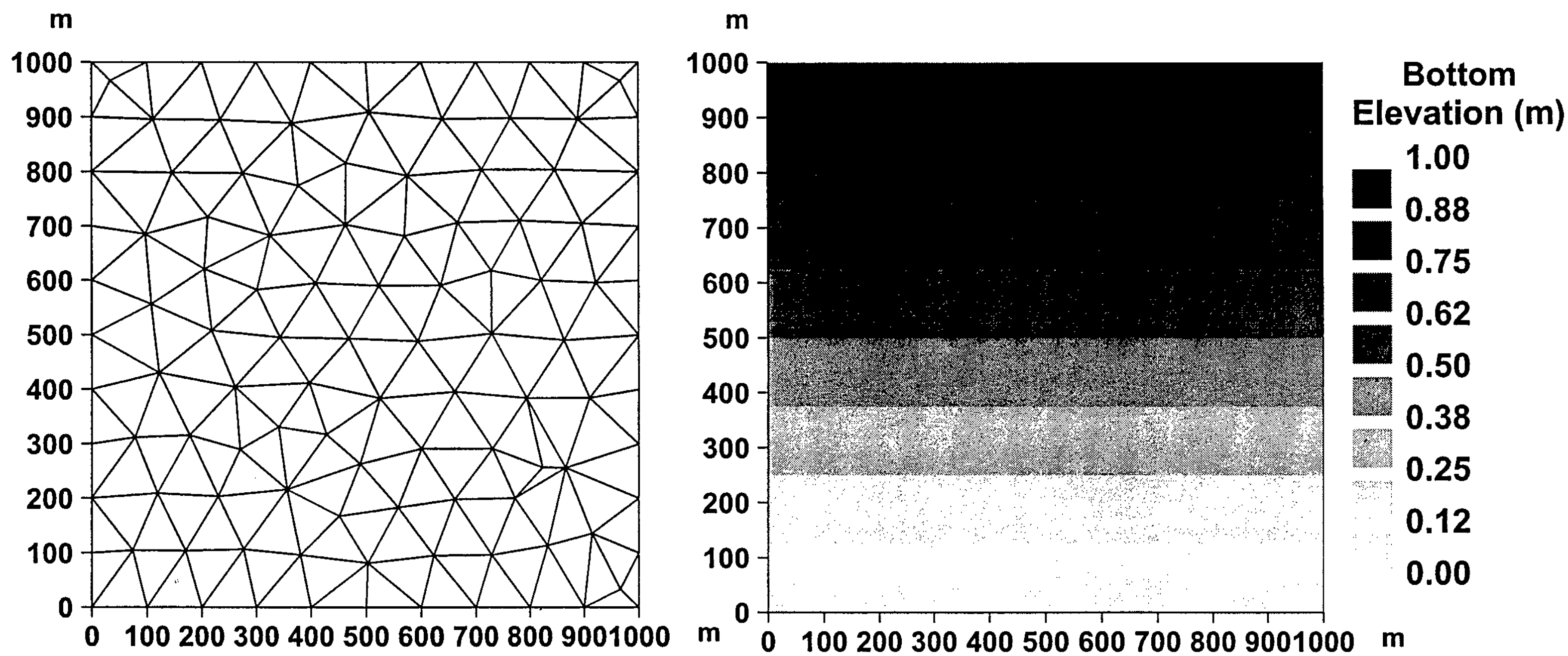
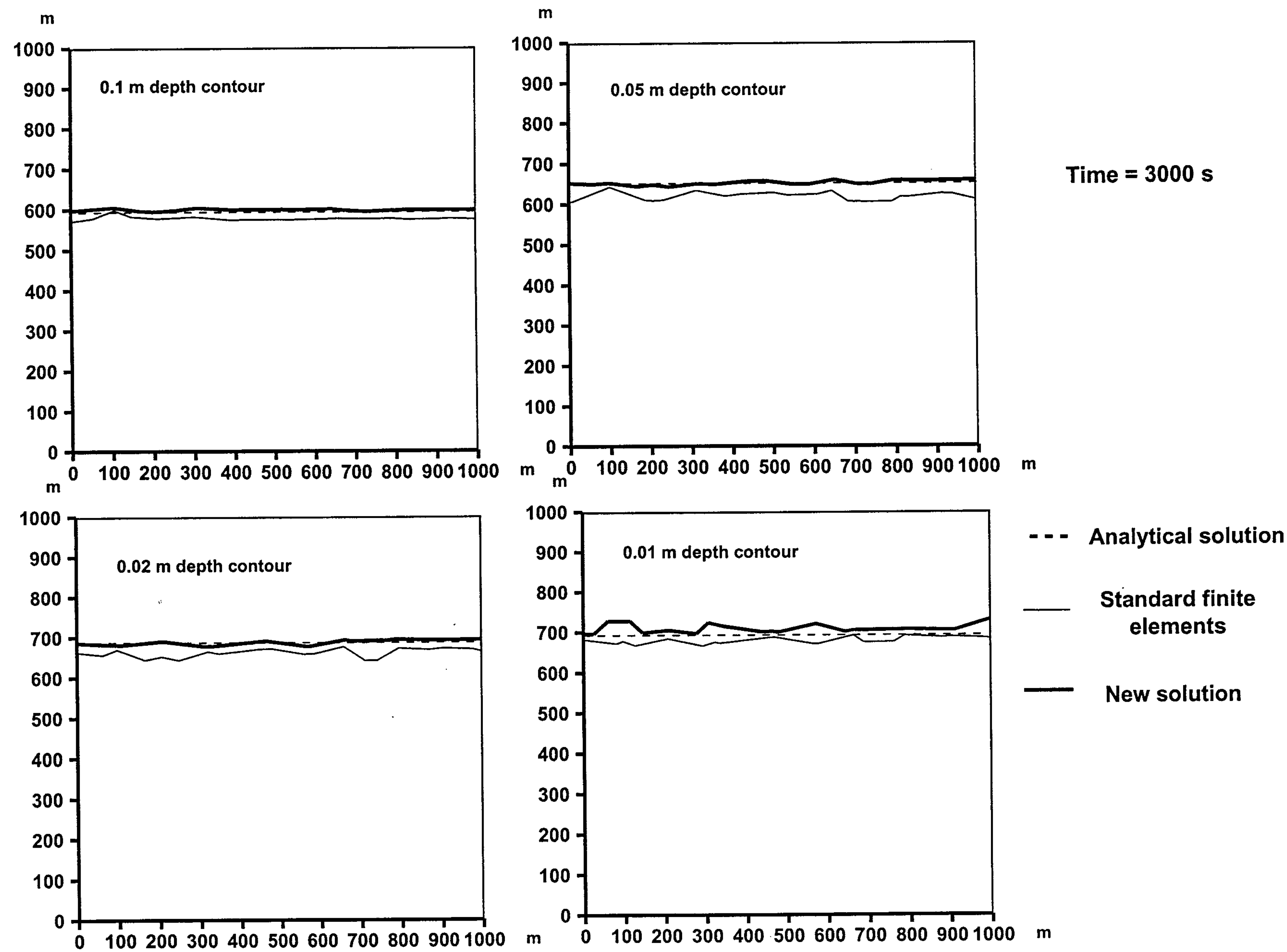
Dynamic moving boundary problems are a common occurrence in shallow water hydraulics, yet no generally applicable or computationally efficient framework is available for their solution. For this contract a new scheme has been developed that attempts to solve the problem of representing moving boundary shallow water hydrodynamics on fixed numerical grids. The scheme consists of three parts: identification of partially wet elements, the development of physically appropriate treatments to deal with mass and momentum conservation discrepancies in such areas within a two dimensional finite element framework and the development and testing of a proof of mass conservation for the new scheme. In particular, the algorithm is unique in distinguishing between flooding and dam-break partially wet elements in contrast to previous solutions to this problem which typically treat both types in a similar fashion. In reality, consideration of the problem physics shows that mass and momentum conservation discrepancies can only be positively identified and corrected on elements of the flooding type. Accordingly, this disaggregation of partially wet elements into flooding and dam-break types is the approach adopted. This new scheme has been tested against a structured series of numerical experiments including objective tests, a newly developed analytical solution for this problem and a unique high resolution topographic data set recently collected for an area of tidal beach on the eastern coast of the UK. The new scheme is shown to be physically realistic, mass conservative and to appear to offer a significant improvement over standard finite element techniques.

Figure 1: Finite element mesh and topography representing a planar beach generated as a simple analytical test case for wetting and drying problems. The cell resolution is approximately ~100 m.

Figure 2: Comparison of wetting phase shallow water depth contours predicted by standard finite elements and the new technique developed in this paper to the analytical solution at 3000 s into the simulation. The 0.1, 0.05, 0.02 and 0.01 m contours should be positioned, respectively, at $y = 600$, 650, 680 and 690 m.



m
1000
900
800
700
600
500
400
300
200
100
0
0 100 200 300 400 500 600 700 800 9001000 m
Bottom
Elevation (m)
1.00
0.88
0.75
0.62
0.50
0.38
0.25
0.12
0.00


Time = 3000 s
0.1 m depth contour
0.05 m depth contour
0.02 m depth contour
0.01 m depth contour
m
0 100 200 300 400 500 600 700 800 900 1000
Analytical solution
Standard finite elements
New solution